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AUTHOR	Kellerman, Anne; MacDonald, Geraldine
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ABSTRACT

A new approach to computer-assisted instruction (CAI) called Author Tutorial System (ATS) was field tested in a National Science Foundation-sponsored school consortium in New York State. ATS was designed as a package of authoring functions written in the APL interactive programing language to enable authors who are not experienced programers to create sophisticated computer-mediated tutorials. A summer workshop held for 72 faculty from the participating schools offered them new uses for CAI, stressing non-linear programs and introducing them to APL. A weekend workshop held in the fall and consisting of lectures and terminal sessions taught faculty members how to develop and revise their own tutorials. Following this, participants developed tutorials for their classes. The conclusion was reached that ATS could make significant contributions to undergraduate education provided two conditions were met. First, a dynamic relationship must be maintained between: 1) originators, 2) programers, 3) computer teaching professionals acting as interface personnel, and 4) faculty, to insure the effective delivery of programing packages. Secondly sufficient attention must begiven to training faculty. (PB)

A DYNAMIC TUTORIAL SYSTEM : AN APPLICATION PACKAGE FOR EVERYONE

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Anne Kellerman and Geraldine MacDonald
State University of New York at Binghamton
Binghamton, New York 13901
Telephone (607) 798-4911

ED 082466

This paper is not about the benefits, advantages or disadvantages of Computer Assisted Instruction (CAI) or of the particular CAI system described in this paper. Rather, it is about the effect of a new approach to CAI called ATS (Author Tutorial System)[1] on our NSF consortium.[2] ATS was developed by a doctor, a dentist and a programmer at Cornell Medical School in New York City, (Hagamen, M.D.; Weber, D.D.S.; Linden; Murphy, M.A.;). It is written in a computer language called APL[3] and runs from an ordinary terminal typewriter. This system was used in a massive field test for the first time outside the medical profession by the fifteen schools (community and four-year undergraduate schools) in New York State, participating in an NSF-sponsored faculty consortium, for development in the use of computers in undergraduate curricula. What we would like to describe are the advantages of having a dynamic relationship exist between the creators of ATS, the faculty of our consortium, ourselves (the teachers of ATS), and the potential students, some who have already used the ATS result: the tutorial! This paper is also about our experiences with teaching ATS according to what we have learned to be effective teaching techniques for a computer-oriented workshop for faculty. Finally, most importantly, this paper is about the degree of commonality provided by ATS and APL among an extremely diverse and heterogeneous group from which our consortium is constructed. In the past, when teaching computer languages to novices, we have been most successful in groups where there is some prior common ground, such as all participants in a class having a scientific background. We found that while we were describing ATS we could reach every one of our listeners with a

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EM 011 485

minimum of difficulty without resorting to discipline or skill groupings.

Before we proceed we should present some definitions to keep the rest of the discussion on common ground.

1. ATS - a package of authoring functions written in APL that enable a potential author to create sophisticated computer-mediated tutorials without the necessity of knowing APL.
2. APL - (A Programming Language) - an interactive programming language based on a mathematical notational scheme developed by Kenneth Iverson.[3] Programs can be written, executed, and stored from typewriter-like terminal locations at any distance from a central computer.
3. Authoring functions - these are programs which are stored on the APL system which allow a faculty member - "author"-to enter questions and answers for his tutorial and edit his work at any time, essentially by typing one or two-word commands.
4. Computer Mediated Tutorial - ideally this is a computer simulation of a live procedure in which a student and instructor (the computer terminal) go through a series of questions and answers until the instructor is sure that the student understands the material. At anytime the student may ask the instructor a question and at anytime the instructor may provide a more detailed explanation, if necessary, about something of which a student has no knowledge. From these ideas Hagamen and Weber constructed ATS.
5. Sophisticated - a tutorial consisting of the following items is fairly "sophisticated": (A) It does not waste the student's time if he already understands the information. (B) It provides an optionally, author controllable, random question selection. (C) Depending on an individual's answers, the tutorial which responds

is individual to each student. (D) The tutorial must be able to handle the student response of 'I don't know'. (E) The student must be able to ask his own questions in free format. (F) A facility must exist for the instructor to go back and study the student's attempt at the tutorial. At this point the capability for easily modifying the tutorial must exist if necessary.

6. To create - means taking subject matter which you, as a teacher, are familiar with and constructing questions and an anticipated and unanticipated response scheme, which will determine the student's knowledge of the subject and tutor him on what he does not know.
7. The authoring package should not rely on a great degree of programming skill. Essentially this means that a person needs only about a one-hour introduction, in our case, to APL to have enough knowledge to proceed on to ATS. If a teacher's sole use of the computer is for tutorials, then he need not learn any more APL.

In July, 1972 we were given ATS by a CAI researcher, Dr. Harvey Long[4] of IBM who had acted as a technical consultant to the creators of ATS. Although the ATS tape had been given to six other schools, at all these places its use had degenerated into a conventional CAI mode. This was not at all the original intent of ATS. This degeneracy into the simplest CAI mode came about primarily because only the distribution tape came. All transported programming requires people on both ends to successfully integrate the package. To the creators, our network represented a chance to see the effect of ATS in many disciplines very different from medicine, on many different levels, by many different types of educators.

At Binghamton, the first main effort under our NSF grant was to present a workshop for the fifteen participating schools to introduce faculty to the capability of computers and their use in the classroom.

We chose APL to be the primary computer language which we would present. Although ATS was available for our kickoff workshop, we were very reluctant to introduce it at that time for several reasons:

1. We have never been strong advocates of the traditional CAI approach simply because the potential of APL used directly or at least in simulations fulfilled most of our needs. The very job of keeping up with these projects kept our limited staff quite busy.
2. The intent of the kickoff workshop was to inspire and offer new ways of using the computer rather than offering the temptation of locking reluctant novices into using only one canned program in a traditional CAI mode.
3. We were afraid that ATS presented at that point in time would offer an easy and attractive alternative to learning the full capabilities of APL. Despite the ease of use of APL, it does look very oppressive on the surface, especially for people in the arts and humanities departments (twenty-seven out of seventy-two participants).

As part of our workshop we did have Hagamen, Weber and Linden come to Binghamton to present an afternoon session on ATS, but only toward the end of the last week. The talk was just an overview of the subject and very little detail was presented as to the technical use of ATS. This short introduction was enough to tantalize about 50% of our participants. Immediately a demand for a subsequent workshop to devote time entirely to ATS was created.

By this time 95% of our seventy-two participants were enthusiastic about the use of computers in their classroom and very interested in continuing to use APL. About half were competent programmers. This distribution of competency spread across all disciplines and to both

the participating community colleges and the four-year colleges. Only about 30% of the faculty attendees were interested in doing a large amount of programming for the projects they had in mind. However, much as we expected, 60% were particularly interested in using ATS.

1. They saw a valid need for a CAI capability in their classrooms. This was most evident in community colleges where at least in New York State teachers have over 18 hours of class contact time and face various levels of student skill.
2. For the arts and humanities, CAI was a logical approach especially with a CAI system such as ATS that has the capability of free student response, or exact syntactical analysis. ATS also permitted using already existing APL functions, some of which had been written during our workshop by the participants. This feature of ATS also made it very attractive to the hard sciences. The key encoding algorithms for encoding of large amounts of material relevant to a specialized field could effectively be used since the participants had some knowledge of APL. In the past it has been easy to find good computer applications in fields such as mathematics, chemistry, physics, and statistics. ATS seemed to be a beginning for people in the arts and humanities where only a very small base of background material existed.
3. In addition, a tutorial can have the facility to allow the student to use the power of APL by using APL as a calculator or even writing his own programs and then be branched back into the tutorial (see Appendix I.)
4. Of course, we have to realize that for some of our participants, ATS offered an easy way to succeed, after what to some was a difficult summer of fulfilling their NSF obligation.

Two months after our initial workshop was over, and all the participating schools had their terminals up and running, we decided the timing was strategically right. Our participating faculty would be ready for a special workshop on ATS. By bringing people back to Binghamton for a workshop at this time we revitalized a lot of the enthusiasm towards computers created during our summer workshop. We planned a two-day session over a weekend consisting of lectures interspersed with assigned terminal sessions. We required advanced preparation consisting of each participant preparing several question-answer sequences using material from their area of specialty. They were given an ATS dictionary, containing definitions of essential ATS keywords, and a question form to outline the procedure of developing a good question-asnwer sequence, keeping in mind the educational philosophy of ATS. Advanced preparation was the key to the success of our ATS workshop, allowing for true dynamic interaction between us, the teachers, and our participating faculty in areas relevant and familiar to both of us.

Everyone was at a common level in programming skill. We no longer felt it necessary to divide our class according to discipline, previous skill, or potential uses. We decided to exercise a long-standing belief that programming and programming applications in particular, were really independent. ATS offered commonality to all fields and allowed us to have a perfect medium to test this theory.

Our lectures were divided to teach the technical aspects of ATS, one at a time, from the most general to the most trivial. After each half-hour lecture a terminal session followed. We kept the classes very small, often repeating the same session twice, allowing alternate groups in the terminal room. When each group was on the terminals they were assigned specific things to work on, related to the specific

aspect of the preceeding lecture and using their advanced prepared material.

A. First the participants were asked to run through tutorials written in ATS on how to use ATS. From this all the participants learned about how students feel when they sit at a terminal taking a tutorial. They were aware of the pitfalls of the system before they themselves made the same mistakes. These tutorials were written by Hagamen and Weber, but cannot be used as a sole source of instruction about ATS. This conclusion was drawn at this time by several participants who had illusions of tutorializing their entire department's curriculum.

B. Each participant was asked to begin authoring a tutorial using his prepared questions and anticipated responses. In this way they could actually use the authoring features of ATS as they learned about them.

C. The terminal sessions were constantly supervised by one of us when the other was lecturing. At this time we were able to personally view the participants' tutorials and add suggestions for improvement to conform more naturally to the original intent of ATS. The workshop became practical rather than theoretical, an essential aspect for all computer-oriented work. One of the largest stumbling blocks to overcome was the concept of a linear tutorial, the traditional method for CAI. ATS was designed to be anything but linear. To utilize ATS fully, one authors from the point of view of testing the student on only what he does not already know. During the terminal sessions we were able to clarify questions arising from the lectures, in many cases demonstrate on the terminal an actual case in point, and suggest more effective use of all ATS facilities.

A. Kellerman, G. MacDonald

D. When the participants returned to lectures they were able to follow new material more intelligently based on the knowledge they had already gained about ATS. They could ask questions of the instructor which were much more direct and to the point. Although the advertised claim of ATS is true, no APL knowledge is necessary, it was fairly obvious to the participants that their familiarity with programming and terminal systems, gave them a tremendous intuitive advantage and at the proper moment.

We had three objectives for this workshop:

1. Each participant was to have started and moved well on his way to completing a tutorial.
2. We wanted the concept to be formalized that all programming efforts, not only ATS, are never really completely finished. (ATS provides, with its student trace facilities, excellent motivation in this direction.)
3. We hoped everyone would develop some intuition about ATS which would allow them to progress independently after they went home.

Seeing the progress of many tutorials in fields from speech to physics, we feel that we were successful. Appendix I includes a small selection of examples which we consider unique in subject matter and approach and help to demonstrate the numerous options of teaching ATS. The variety of disciplines is indicative of some degree of success with teaching one computer application to a highly heterogeneous group.

Our participants were encouraged to call us whenever they had a problem with ATS. These calls began to arrive on a regular basis after the workshop was over.

We would like to relate one incident by way of example of the continuing interaction. One of our chemistry professors wrote a tutorial

at our workshop. He went back to his school with it and tried it out on some students. His students provided natural feedback through the trace feature on ATS and through face to face conversation. He then began adding to his tutorial, mostly new anticipated responses which he did not include or anticipate originally. One of the true drawbacks of APL now came into play. The size of a tutorial is limited to the size of a workspace in APL (36K). This can be overcome by instructing the student to move to a new workspace; however, some finite subset of a tutorial must remain in one workspace. Our faculty member filled up one workspace and found he was unable to do anything else with the conventional editing facilties of ATS. After realizing it was physically impossible to extend the size of his workspace, which required many phone calls, he later found a reasonable solution in conjunction with us. We all learned from this one case. We have since discovered other limitations of ATS and ways to get around them.

After the workshop ended we related, to the creators of ATS, information gathered when thirty-five people from many different interest areas with many different instructional techniques began experimenting with a system to its limits. A lot of bugs, potential problems and suggestions for improvements were written up and sent to Hagamen, Weber and Linden, according to prior agreement. They also helped us in supplying visual aids for teaching purposes and volunteering to come to our workshop as well. Something worth noting here is that we did not really want or need them as teachers, but rather as technical advisors. We have learned from experience that teaching computing really takes a computer instructional applications professional and not someone who is a professional in some other form of education. The teaching of a group such as ours demands experience in talking across disciplines about specific disciplines and familiarity with debugging other people's work.

A. Kellerman, G. MacDonald

The main point to conclude with is that programming packages for undergraduate curricula, if they are to be truly transportable, must also contain that element of cooperation between originator and final destination, including all those people in between. At the final destination three groups of people are vital: technical programmers for installation, computer teaching professionals to act as interface, and of course, the faculty. Only the people at the destination are truly capable of effectively incorporating it in their domain.

FOOTNOTES

1. A Tutorial System (ATS) Concepts and Facilities Manual Preliminary Version - Hagamen, M.D., Weber, D.D.S., Linden, Murphy, M.A., Cornell Medical School, New York.
2. NSF - GJ33144
3. APL 360: User's Manual, A.D. Falkoff, K.E., Iverson, IBM Corporation.
4. Dr. Harvey Long , IBM Corporation, Department 843, Industry Systems Center-Instruction, 10401 Fernwood Road, Bethesda, Maryland.

APPENDIX I

The responses to the □: are the student's response.

```
**************************
  COMMENT?
THIS IS A DANDY TUTORIAL
**************************
□:
HELP ME PLEASE
  WE WILL HELP YOU

  TK=TC + 273.15. SO FIRST YOU HAVE
  TO CONVERT THE FAHRENHEIT
  TEMPERATURE TO WHAT


  AT WHAT TEMPERATURE DO THE
  FAHRENHEIT AND KELVIN SCALES GIVE
  THE SAME READINGS?
□:
CALC

  APL CAN BE USED AS A CALCULATOR. IF
  YOU DO NOT KNOW APL LIMIT YOURSELF
  TO SINGLE MATH CALCULATIONS.
  O.K.(ANSWER YES OR NO)
□:
YES
□:
      273.1×9÷5
491.58
□:
      F


  AT WHAT TEMPERATURE DO THE
  FAHRENHEIT AND KELVIN SCALES GI
  THE SAME READINGS?
□:
575.375
  THE CORRECT ANSWER IS 575.375


  EXPRESS THE NORMAL HUMAN BODY
  TEMPERATURE 98.6 F ON THE
  CENTIGRADE SCALE.
□:
WHAT
  I DON'T UNDERSTAND YOUR QUESTION
□:
WHAT IS CENTIGRADE

  TO CONVERT FAHRENHEIT TO CENTIGRADE
  TC=5/9×(TF-32) WHERE TF IS THE
  FAHRENHEIT TEMPERATURE AND TC IS
  THE CENTIGRADE TEMPERATURE.
  NOW WE'LL RETURN TO WHERE YOU WERE BEFORE ASKING YOUR QUESTION

  EXPRESS THE NORMAL HUMAN BODY
  TEMPERATURE 98.6 F ON THE
```

A student can enter a comment at any time. This comment is saved for later use by the tutorial author.

***

ATS itself chooses the most appropriate help branch, unless the author desires to specify one.

***

In the tutorial directions, a student was instructed to type CALC to enter APL calculator mode, and F to return.

***

ATS has recorded the student's difficulty on the first question. If a student answered the question correctly, the first time, he would have been branched out of the tutorial.

***

ATS attempts to match and branch on any student response, if possible.

***

```
DISPLAYALL

SEGMENT 1:  12 AQ'S
  1  1.1  2  3  4  5  7  8  9  10  11  12

AQ1:
  NAME THE COMPOUND C9H11BR THAT HAS THE FOLLOWING NMR SPECTRUM: QUINTET
  T 7.85(L 2.15),2H; T 7.25(L 2.74), 2H; TRIPLET T 6.62(L3.38),
  2H;SINGLET T 2.78(L 7.22), 5H. CHOOSE YOUR ANSWER FROM THE FOLLOWING
  LIST OF COMPOUNDS: 1 BROMOETHYLTOLUENE, 1 PHENYL 2 BROMOPROPANE, 1
  BROMO 3 PHENYLPROPANE, 1,1 BROMOPHENYLPROPANE,2 BROMO 2 PHENYLBUTANE,
  1,2,3,BROMOETHYL METHYLBENZENE BENZENE.
    NEG: NO NOT NEVER DON'T
    AA1:
      1. 1 BROMO 3 PHENYLPROPANE (ORDER)
AA RESP: (→0)
  CORRECT. YOU SEEM TO UNDERSTAND THIS MATERIAL. TRY ANOTHER QUESTION BY
  TYPING TUTOR AGAIN.
    AA2:
      1. 1 PHENYL 2 BROMOPROPANE (ORDER)
      2. 1,1 BROMOPHENYLPROPANE (ORDER)
AA RESP: (→2)
  WRONG. PLEASE REEXAMINE THE DATA.
    AA3:
      1. 1 BROMOETHYLTOLUENE (ORDER)
      2. 1,2,3,BROMOETHYLMETHYLBENZENE (ORDER)
AA RESP: (→3)
  INCORRECT. REEXAMINE THE DATA.
    AA4:
      1. 2 BROMO2 PHENYLBUTANE (ORDER)
AA RESP: (→1)
  WRONG. PLEASE COUNT UP THE NUMBER OF CARBON ATOMS IN THE COMPOUND AND
  TRY AGAIN.
UN RESP: (→1)
  PLEASE CHOOSE YOUR ANSWER FROM THE COMPOUND NAMES THAT ARE GIVEN.

AQ1.1:
  NAME THE COMPOUND C10H14 WITH THE FOLLOWING NMR SPECTRUM; DOUBLET T
  8.8(L 1.2),6H; SINGLET T 7.7(L 2.3) ,3H; MULTIPLET T 7.2(L 2.8),1H;
  SINGLET T 3.0(L 7.0),4H. CHOOSE YOUR ANSWER FROM THE FOLLOWING
  COMPOUNDS: T-BUTYLBENZENE, SEC-BUTYLBENZENE,P-ISOPROPYLMETHYLBENZENE,
  2-PHENYL-2-BUTENE, P-CYMENE, TETRAMETHYLBENZENE,P-ISOPROPYLTOLUENE,
  ETHYLDIMETHYLBENZENE, N-PROPYLTOLUENE.
    NEG: NO NOT NEVER DON'T
    AA1:
      1. P-ISOPROPYLMETHYLBENZENE (ORDER)
      2. P-ISOPROPYLTOLUENE (ORDER)
      3. P-CYMENE (ORDER)
      4. P ISOPROPYLMETHYLBENZENE (ORDER)
      5. P ISOPROPYLTOLUENE (ORDER)
AA RESP: (→1)
  CORRECT THE COMPOUND HAS AN AROMATIC RING, A GROUP,AND AN ISOPROPYL
  GROUP. YOU TO UNDERSTAND THE MATERIAL.
```

Tutorial written by:
Dr. Robert Silberman
State University College
at Cortland

A. Kellerman, G. MacDonald

```
     TUTOR
  PLEASE ENTER YOUR NAME:
GERRY


  WHAT IS DEATH?
□:
NOT LIFE
  I'M NOT SURE I UNDERSTAND THAT. LET'S APPROACH THE PROBLEM FROM A
  DIFFERENT ANGLE.

  ARE LIFE AND DEATH OPPOSITES OF THE HOT-COLD SORT, OR OF THE ON-OFF
  SORT?
□:
ON OFF
  WE MUST EXPLORE SOME OF THE CONSEQUENCES OF THAT ASSUMPTION.

  HOW MANY DIFFERENT STATES OF EXISTENCE ARE POSSIBLE IN AN ON-OFF
  UNIVERSE?
□:
2
  VERY GOOD. IN AN ON-OFF UNIVERSE THERE ARE ONLY TWO POSSIBLE STATES OF
  EXISTENCE: ON OR OFF.

  IN THE CASE OF HEAT AND COLD, HOW MANY DIFFERENT TEMPERATURES ARE
  POSSIBLE?
□:
INFINITE
  AN INFINITE NUMBER OF TEMPERATURES MAY EXIST.

  DOES IT NOW SEEM TO YOU THAT A MAN IN THE TERMINAL STAGES OF CANCER
  SUDDENLY GOES FROM 'ON' TO 'OFF' OR DOES HE SEEM TO SLIP GRADUALLY
  AWAY, LIKE THE MERCURY SLOWLY SINKING LOWER IN A THERMOMETER?
□:
SLIP GRADUALY AWAY
  I DON'T UNDERSTAND THE MEANING OF: GRADUALY
□:
SLIP GRADUALLY AWAY


  WHAT IS DEATH?
□:
```

Tutorial written by:
Mr. Frank Zindler
Fulton-Montgomery
Community College

A. Kellerman, G. MacDonald

```
        TUTOR
    PLEASE ENTER YOUR NAME:

JANE


  CLASSIFY THE ORDINARY DIFFERENTIAL EQUATION Y'''+2(Y'Y)+A(X)Y-2=0.
□:
NONLINEAR SECOND ORDER HOMOGENEOUS
  YOU HAVE GIVEN A RESPONSE THAT I DON'T UNDERSTAND---THIS MAY BE DUE TO
  SOMETHING AS SIMPLE AS A SPELING MESTAKE OR IT MAY BE THAT YOU DO NOT
  UNDERSTAND THE SIGNIFICANCE OF ONE OR MORE OF THE ATTRIBUTES. IN ANY
  EVENT, NOW THAT YOU'RE HERE LET'S CONSIDER SOME QUESTIONS OF A LESS
  COMPLEX NATURE.

  IS THE EQUATION Y''+(X*2)Y=0 LINEAR OR NONLINEAR?
□:
NONLINEAR IT LOOKS TO ME
  WRONG!AN EQUATION IS NONLINEAR IF ANY TERM IN THE EQUATION HAS THE
  DEPENDENT VARIABLE(Y) OR ANY OF ITS DERIVATIVES(Y',Y''...) APPEARING
  IN COMBINATION OR RAISED TO A POWER OTHER THAN ONE(1).

  IS THE EQUATION Y''+(X*2)Y=0 LINEAR OR NONLINEAR?
□:
LINEAR
  THAT'S RIGHT!THE EQUATION IS LINEAR.

  IS THE EQUATION Y'''+2(Y'Y'')+8Y=0 LINEAR OR NONLINEAR?
□:
QUT
 **ABNORMAL TERMINATION**
  COMMENT?
I'M TIRED AND WANT TO GO HOME

          TRACE
  12/22/72  JANE

  SEGMENT 1
     AQ: 1.1
  *****  NONLINEAR SECOND ORDER HOMOGENEOUS
     AQ: 3  3  4
  **COM  **ABNORMAL TERMINATION** I'M TIRED AND WANT TO GO HOME

  TIME: 3 MIN. 34 SEC.
```

Tutorial written by:
Dr. Stuart Pergament
SUNY Maritime College

ATS WORKSHOP SCHEDULE
Go to either A or
B
SATURDAY

	A	B	Reading Assignment
10:30 - 12:00	Main Lecture (Manuals & References will be distributed)		#1, #2, #3, #4, #5, #6, #7, #8, #18, #19, #20, #21, #11, #12, #13, #23, #32, #33
12:00 - 1:00	Lunch	Terminal	Take 9 ATS1 and 9 ATS2. Enter one of your questions.
1:00 - 2:00	Terminal	Lunch	
2:00 - 2:45	Branching	Terminal	#37, #38
2:45 - 3:30	Terminal	Branching	Take ATS3 & ATS4
3:30 - 4:30	EDIT		#8, #10, #14, #15, #15A, #16, #17, #22, #24
4:30 - 5:00	APL functions	Terminal	Take 9 ATS5
5:00 - 5:30	Terminal	APL functions	#38, #49, #50

SUNDAY

	A	B	Reading Assignment
9:00 - 9:30	Subject Questions Subject of AQ's	Terminal	#25, #26, #27, #29, #39, #46
9:30 - 10:00	Terminal	Subject Questions - Subject of AQ's	
10:00 - 10:30	Terminal	LISTS in ATS	#28
10:30 - 11:00	LISTS in ATS	Terminal	
11:00 - 11:30	Trace & Cleanup	Terminal	#34, #35, #36, #43, #44, #45
11:30 - 12:00	Terminal	Trace & Cleanup	
2:00 - 3:00	General Session		

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